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Skeleton Prototype Software Detection and Feature Extraction of Non-intrusive On the gait of Man In Real Time

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Abstract. Every human being created by God to the bone structure and shape of the body that affect the attitude of walking human or human gait with a unique karakaterikstik. Human gait analysis can be implemented on a medicine to help doctors diagnose patients with gait disorders, designing a program of rehabilitation and prosthetic design. In the sports field is used for the analysis of human gait trainer consideration in identifying the best techniques to improve the performance of athletes, explaining the ways of safe and effective in performing gait athletes to avoid the risk of injury in athletes, implement the strategy, the pattern of training and therapy to athletes in accordance with physical condition of each. This paper discusses the software prototype skeleton detection and feature extraction of non-intrusive to the human gait in real time. The first stage of human gait analysis is the acquisition of objects of human gait using Logitech webcam in real time VidTmHD 9000. The second stage is composed of pre-segmentation process and the formation of a silhouette. In the pre-process each frame gait resulting from the acquisition of human gait are processed using the method of background subtraction. Subsequent formation of the human body silhouette with a method of filtering, thresholding, dilation, erosion, and inversion. Skeletonizing the third stage, the process of skeleton formation using the method of thinning. The last stage is the feature extraction process parameter measurement of the distance geometry calculations using both feet of space to obtain the coordinates of each frame image of the skeleton of human body parts of both legs at all times. Based on the test results it was concluded the acquisition method of human gait in real time managed to make the acquisition of human gait quickly so that the data of human gait can be directly processed to detect the skeleton and extracting features automatically, quickly and accurately. Background reduction method can effectively separate the object mensegmentasi and ongoing human body from other objects in the image captured by the Webcam. Methods of filtering, thresholding, dilation, erosion, and the inversion result of the human body silhouette running. Method of skeletonizing and thinning of the human body silhouette running to produce the skeleton of the human body is almost like the real form. Calculation of the features of human gait is the distance between the front legs to the back of the heel, the difference in height between the front foot with the heel of the hind legs, the distance between the front knee to knee and back foot difference in height between the front knee behind the knee can be performed automatically without operator intervention or non-intrusive in a relatively fast.

Keywords: Gait, Realtime, Acquisition, Skeleton, extraction

1. Introduction

Every human being created by God to the bone structure and body shape are different from one another. In the course of time various factors such as environmental and accident may influence the shape of the human body. The unique body shape influence on human gait.

Gait is a style or attitude of human walking [3]. Every human has a different gait. Human gait has the advantage in the acquisition process can be done from a distance and difficult to hide or engineered [2]. Human gait analysis can be implemented in various areas of life, such as medicine and sports. In the medical field, particularly with respect to the physical branch of medical science and medical rehabilitation, human gait analysis may help doctors diagnose patients with gait disorders, rehabilitation program design and the design of prosthetic / orthotic (improvement of limb function loss, correcting defects, prevent disability more) in accordance with the structure of the human body. In the field of human gait analysis exercise is used to study the gait of athletes. The science known as biomechanics. The use of this knowledge becomes important when athletes gait analyzed by a computer software that contains data about the mechanics of the formula. Formula which is the application of mechanics in this sport athlete outlining how the gait can be very effective and efficient so as to improve performance. Athletes gait analysis was then used as a grip trainer to give the correct instructions to the athletes. On some basic sports such as athletics, conducted in-depth assessment in terms of body work techniques and strategies so that athletes can improve performance. In every athlete's gait training or match is recorded and stored in the database. Furthermore a computer software used to analyze the gait of athletes. Visualization is displayed by the computer can replace the coach's eyes, so the results more quickly and accurately. The results of this analysis into consideration the coach in identifying the best techniques to improve the performance of athletes, explains safe ways of doing an effective gait to avoid the risk of injury in athletes, implement the strategy, the pattern of training and therapy for athletes according to their physical condition [1].

In general, human gait analysis phase includes the acquisition of the object (body movements), body shape segmentation, extraction and matching the results of extraction with the database. In the early stages, the data acquisition that is the object of human gait obtained by video recording and image capture directly (real time) via webcam. The results of the acquisition of the object is the basis for further processing. In the segmentation phase, each frame gait resulting from the acquisition of objects is processed to produce a silhouette of the human body and further processed to form the bones (skeleton) or order. Phase extraction is the process of measuring the parameters of distance, angle and speed of calculation using the geometry of space to obtain the coordinates of each digital image frame skeleton major part of the human body at any time [7]. In the last stage of the visualization results of the extraction can be directly analyzed by experts in the medical field or sports. The process of gait analysis by experts can be replaced by computer-based analysis. These results can be used as a base to see the extent of the effectiveness of gait of the object photographed by the standards of good gait and useful and efficient.

Several studies on human gait has been developed based on the skeleton. This method of recognizing human gait based on the skeleton through video recordings of human gait. Distance of feature extraction is still performed manually by mendigitasi directly on the screen using the cursor to determine the location of the joints in the skeleton [5]. Human gait and posture analysis to determine the neurological disorder has not been done in real time but through video recording. Gait image acquisition methods which human beings as its object must use special clothing that is hand colored red, white left leg, right leg and the body is black. This is done to facilitate the skeleton detection, segmentation is performed by combining the object and the background and feature extraction performed to calculate the distance and angle [6]. There also do video recording of human gait are given a colored marker on the body that is red on the head, the pink color on the shoulder and hand, the blue color on the legs. The extraction process is done by giving the same color marker on the skeleton such as a video recording of human gait. The process of forming a skeleton made of video recordings are not in real time [5].

In general, studies have been conducted on human gait analysis through detection of the skeleton has not been done in real time. In addition, the acquisition of human gait still use clothes with special specifications and the use of markers. Similarly, in the process of feature extraction and measurement of the distance between features is still done manually by the print media mendigitasi paper (hardcopy) or through the monitor screen by using the cursor. In other words, the two techniques mentioned above are still using visual interpretation of the operator to determine the position of dots or pixels desired. Thus this study proposes a prototype software topics Skeleton detection and feature extraction of non-intrusive to the human gait in real time.

2. Research Method

This section will explain the methods used to detect the skeleton and the extraction of non-intrusive features of human gait in real time. Broadly speaking, the research methods presented in figure 1.

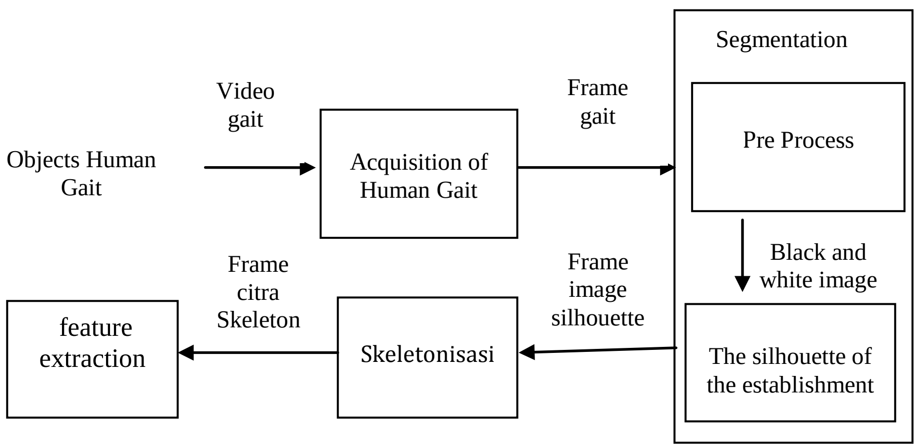


Figure 1: Outline of methods

Data acquisition is the object of human gait obtained through pmelalui video in real time using a webcam (camera integrated with a computer). The results of the acquisition of the object is the basis for subsequent processing of the segmentation process. Segmentation consists of two processes, namely pre-process and the formation of a silhouette. Each frame gait resulting from the acquisition of objects, in this process will then be pre-processed using the method of background subtraction. After that followed the establishment of a silhouette. Formation of the human body silhouette made by the method of filtering, thresholding, dilation, erosion, and inversion. At this stage of skeletonizing, skeleton or framework of the formation process is done through the process of thinning by Hilditch algorithm to produce images with the main object of one pixel. Furthermore the last stage is feature extraction. At this stage the process parameter measurement using a distance of two feet of space geometry calculations to obtain the coordinates of each digital image frame skeleton major part of the human body at any time. Details of each stage of the research described below:

2.1. Acquisition of human gait

In this study the acquisition of human gait using primary data. Primary data is the object of human gait are taken in real time. Acquisition process of the human gait in real time as shown in figure 3.2 using Logitech Webcam VidTmHD 9000 with a distance of 2 meters 10 cm and 60 cm height webcam. Video Frame size 640 x 480 pixels, consisting of the video path and the road bent gently. Acquisition in real time process begins with making the background (background) done next new style of shooting 32 frames of human walking. Frame image of the human gait is a color image. Acquisition of human gait algorithm in Real Time are as follows:

- Acquisition of real time starting with the introduction of the webcam and resolution settings to the computer using the metod videoinput ('winvideo', 1, 'RGB24_640x480').
- Do the configuration of the webcam using the metod triggerconfig (vid, 'manual'), set (vid, 'FramesPerTrigger', 1 and set (vid, 'TriggerRepeat', Inf) and to start a webcam pengambilaan by using start (vid).
- The process of iterations performed 32 times to read per frame using a human gait, trigger (vid) and getData (vid, 1) and keep it in shape. Jpeg. in rinici seen in Figure 2.

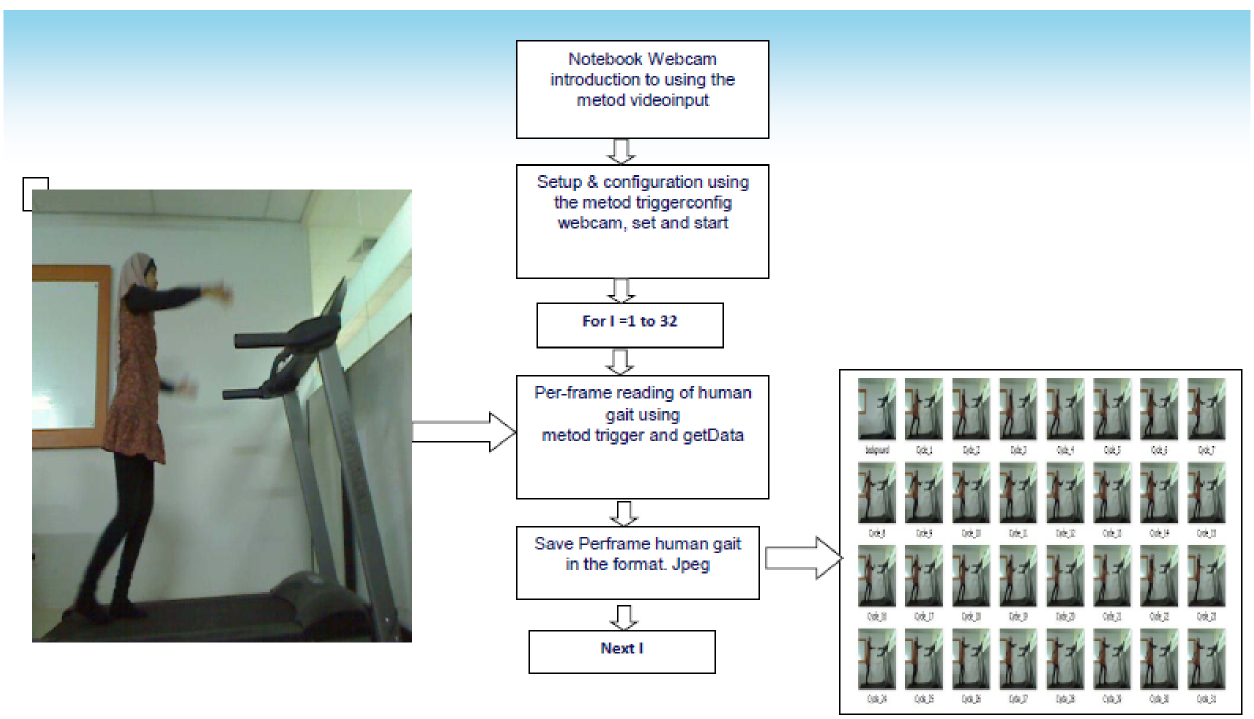


Figure 2: The process of gait acquisition in real time

Object acquisition style of shooting man walks obtained in real time via webcam (camera integrated with a computer), as shown in figure 3.

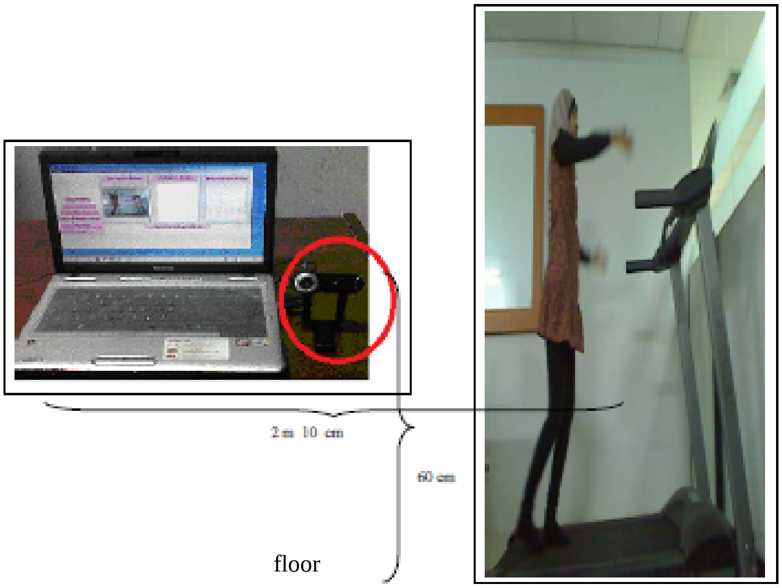


Figure 3: The process of reading the human gait in real time via webcam

Acquisition process of the human gait in real time using Logitech webcam VidTmHD 9000 with a distance of 2 meters 10 cm from the object of human progress, and height 60 cm webcam calculated from the floor.

2.2. Segmentation

Segmentation stage consists of two processes, namely pre-process and the formation of a silhouette. In the pre-process stage, the human gait image frame is processed to generate an image frame cropping has reduced the background. Of pre-process the image frame is then formed his silhouette. In detail, the segmentation process can be described below.

2.2.1 Pre-process

In general, pre-process stage consists of process grayscaling, background subtraction (background reduction) and the cropping process as illustrated in Figure 4.

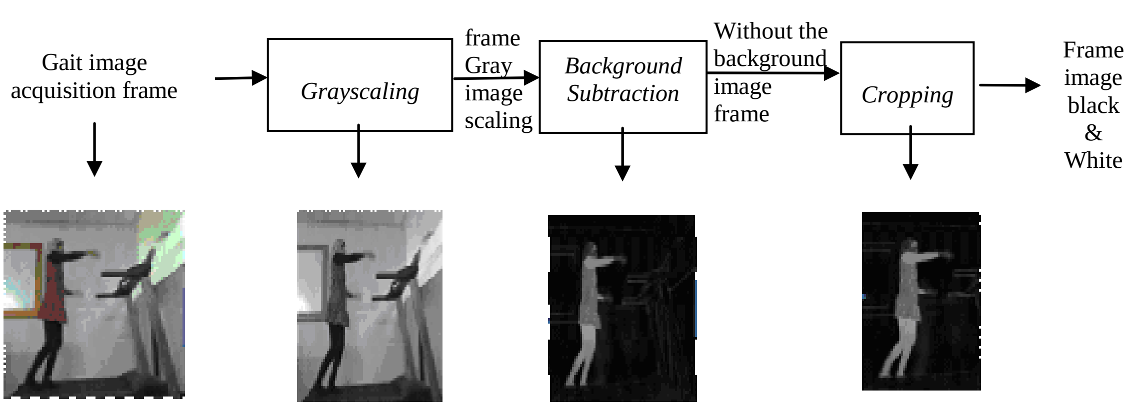


Figure 4: Diagram of pre process

In the process of data input frame image grayscaling human gait in real time. Grayscalling done to change the color of each frame of color image RGB (Red Green Blue) into a gray image (gray scale. Transform the color image can be done through a weighted combination of three colors R, G and B as described in this chapter the theoretical basis and can be formulated as in equation 1.

$$Gray = 0.299\ R + 0.587\ G + 0.114\ B \tag{1}$$

Once the process is done grayscaling background subtraction process (background reduction) using the method of background subtraction. Background substraction process is done by reducing each pixel of the image frame by frame image of the background of human gait in real time is described by equation 2.

$$Q(i,j)=|P_1(i,j)-P_2(i,J)| \tag{2}$$

Where: P1 is a frame image of the human gait in real time.

P2 is the frame background or vice versa.

In this process, the reduction of the background image frame to frame images in real time human gait performed twice. The purpose of the reduction was twice that of all backgrounds and other objects which do not relate to the human body can be removed. If the reduction is only done once, the object is the result of the background substraction is not so obvious and it would be difficult to obtain optimal results in the next process.

After reduction, the next step is the sum of each pixel of the image twice the reduction, which is described by equation 3.

$$S(i,j)=|A_1(i,j)+A_2(i,j)| \tag{3}$$

Where: A1 is the image of the first reduction

A2 is the image of the second reduction

Summation process is intended to get only the human body shape object. Subsequently cropping process that aims to reduce the size of the image, making it more focused on the object image to be examined. Cutting is done by reducing the 10 columns on the left side of the image, then take 480 lines made from one of the top row and also took the 430 columns that be done from the field to 11, so the size of the image to 480 X 430

2.3. The silhouette of the establishment

At the stage of formation of the silhouette, there are several methods used, the process of filtering, thresholding, dilation, erosion, and inversion. In general, the formation stage of the silhouette shown in figure 5.

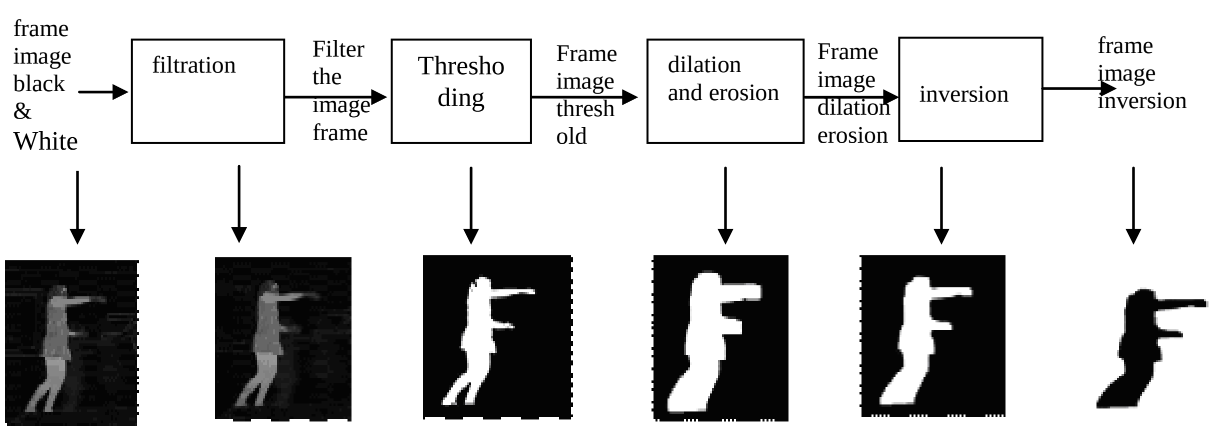


Figure 5: Creation of a silhouette

The early stages of the process of forming a silhouette is filtering. In this study using the median filtering process filter.Pada filtering process, the pixels of each frame image of the human gait in real time will be taken 8 x 8 matrix. The pixel values of the matrix are sorted from smallest to largest, then take the middle value. The middle section of 8 x 8 matrix of pixels for that image will be replaced by the mean of image pixels that have been sequenced.

After the filtering process is complete, then performed thresholding process. In the thresholding process, which acts as the input image is the image that has been through the process of background subtraction and filtering. The workings of the thresholding method is determining a first threshold value. To obtain the threshold value is done by cutting a portion of the image. Part image in the piece is in the background, then the image of the piece is seen every pixel value. If the pixel has a different value of neighboring pixels are stored in the first threshold value. This is done until all of the background of the image, cut and pixel values in comparison. Then the set of threshold values are compared and taken the greatest value to be used as a threshold value in this thresholding process. In detail, the method of thresholding can be described as follows:

- Threshold values obtained in the process of determining the threshold value for the thresholding is 32, so that if the value of the pixel being examined has a value smaller than 32, then the value of the pixel will be changed value to 0.
- But if the value of the pixel being examined has a value greater than 32, then the value of the pixel being examined is to change the value to 255. Figure 3.11 is a flow chart of the thresholding.

In the process of formation of this silhouette, made morphological dilation and erosion operations. For the morphological dilation operation done twice. Dilation of the first process, using a line-shaped structuring element with a length of 12 pixels and take the angle 90^o. Based on the experiments that have been conducted, the length of 12 pixels is the most appropriate long as it matches the shape of the object. After determining the shape of the structuring element in the first dilation operation, then the structuring element are united and form a matrix of 12 x 12. This causes pixels on the boundaries of image thresholding process yield increased by 12 x 12 matrix.

On the second dilation operation, the shape of structuring element used is a line with a length of 17 pixels and the angle of 90^o. Just like the first dilation operation, both forms of structuring element in the second dilation operation, the two forms of structuring element is also incorporated and form a matrix of 17 x 17. This causes pixels on the boundaries of the image of the operating results of the first dilation increased by 17 x 17 matrix.

After the dilation process is completed, the next is morphological erosion operation. This erosion is a process of reduction of pixels on object boundaries. In the process of erosion, the structuring element used by the disk-shaped fingers 12. This causes pixels on the boundaries of the image of the operating results of dilation is reduced by a form of disk radius 12

Completion of the erosion operation, performed on the image pixel value traded is called inversion. Image pixel value was defined as the background pixel value is 0 (black) pixel value is converted into value 255 (white). While the image pixel value was defined as an object that the pixel value 255 (white) pixel value is converted into value 0 (black).

2.4. Skeletonizing

In the skeletonizing process, the input image is converted into a binary image with a value of 0 represents a black pixel (region point) and a value of 1 represents a white pixel (background point). In the process of this change, the threshold method is used with the threshold value is 125.

Finished changing the input image into a binary image, performed skeletonizing process. Beginning of this process is carried out prior to the marking of the 8 neighboring pixels to be in the review. Pixels that will be reviewed are marked as P1.

Skeletonizing process used in this study were skeletonizing algorithm using Thinning by Hilditch. In detail, the Hilditch algorithm is as follows:

- On the pixels that will be reviewed starting from row 3 and column 2 of the image and will end on the line of the image minus 1 and minus 2 columns of the image.
- Pixels that will be reviewed must meet the first condition, ie the pixel value is 0, if the conditions are met then examined whether it meets the four criteria of Hilditch algorithm or not
- Before performing the first inspection, carried out the sum of pixel values that have a value of 0 from the neighboring pixels are viewed (P1).
- Results from the sum of the pixel must be greater equal to 2 and less equal to 6
- The second inspection is done, after calculating the amount of connectivity (displacement value from 0 (region point) to 1 (background point)) of the pixel P1. The number of connectivity should be 1.
- A third examination, after calculating the number of pixels P2 connectivity. Connectivity number must not equal 1 and the value of P2 or P4 daripiksel or P8 there is a value 1 (background point).
- Examination of the four performed, after performing the calculation of the connectivity of the pixels P4. Connectivity number must not equal 1 and the value of the pixel P2 or P4 or P6 there is a value 1 (background point). Skeletonizing process in detail can be seen in Figure 6.

Skeletonizing process is a process that aims to produce the image frame with the main object by 1 pixel. The image is used as the input of the skeletonizing process is the result of the image formation process of the silhouette as shown in figure 5.

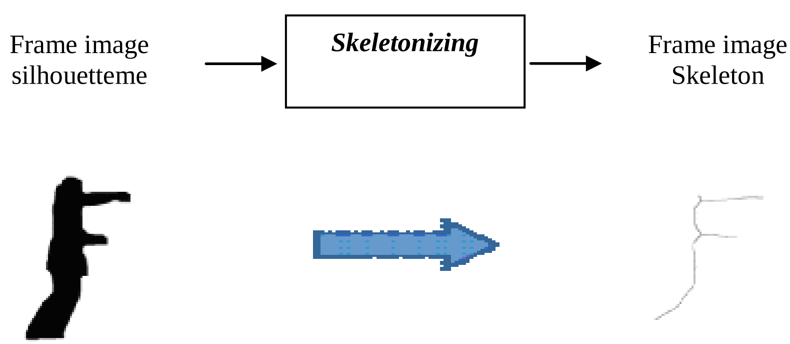


Figure 6: Process Skeletonizing

2.5. Feature Extraction

In the calculation of the extraction process carried out on four features, namely: (1) the distance between the front legs to the back of the heel (F4), (2) the difference in height between the front foot with the heel of the foot back (F3), (3) the distance between the front knee until the back knee (F2) and (4) the difference in height between the front knee behind the knee (F1). Four features are extracted refers to research [5]. At 7 the picture shows the position of all the features to be detected.

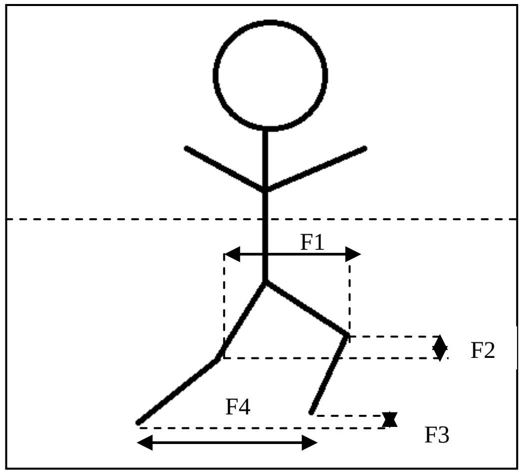


Figure 7: The division of the image skeleton into two parts

From the position of all features shown in figure 7, the features are grouped into two. The division of this group aims to simplify the calculation of the feature to be searched. Within these groupings there are two features that are included in the features of the lower leg, two features that are included in the features of the knee.

Input image is used in the process of image feature extraction is the process of skeletonizing, the skeleton. Skeleton image is then converted into binary image by thresholding. The thresholding process has a threshold value of 24. Threshold limit value of 24 is the most appropriate value to form a binary image. After changing the image of the skeleton into a binary image, the line of the image is divided into two parts, namely the top and bottom. The division aims to narrow the scope of the calculation, so mempemudah in extracting features.

Finish dividing line of a binary image of the skeleton into two parts and grouping features according to the features to be searched, made the process of extracting features in the lower leg. Previously, the line from the bottom of the skeleton image is divided into two parts, the upper leg and lower leg.

After dividing the image of the bottom of the skeleton into two parts, followed by extracting features of the lower leg. Feature is the distance between the front foot with the heel of the foot to the rear (F4) and the difference in height between the front foot with the heel of the foot back (F3).

The first feature to look for is the distance between the front legs to the back of the heel (F4). To search feature F4, the steps taken are:

- Find the column coordinates of the lower leg that has a value of 0 (black). After obtaining the value of the column coordinates of the lower leg.
- Find the minimum and maximum values of the column coordinates. Minimum value column indicates the location of the front legs. The maximum value of the column indicates the location of the heel of the hind legs.
- At the maximum and minimum values of the coordinate points deducted each column and found the F4 features.

Finish getting the F4 feature, the value of other features to be searched is a feature F3. F3 feature values obtained from the difference in height between the front foot with the heel of the hind legs. To search feature F3, carried out by:

- Find the maximum value of the column line (heel cord) and the minimal value of the column lines (front leg) is obtained when the search feature F4 by conducting the process of iteration.

- Iteration process is performed on the skeleton image of the lower leg.
- The results of this iteration process will get the maximum value of the row and column minimal column of the process of extracting features of the F4.
- After getting the value of that line, then look for the difference of the value of that line. The results of the difference is the value of feature F3.

In getting the values of the features on the knee, there are two features to look for, ie the distance between the front knee until the rear knee (F2) and the difference in height between the front knee behind the knee (F1). To obtain the values of the features found in the knee, the knee should be aware of the skeleton image to search features. In this application it is assumed that the center of the foot of the image is the point of the knee, so to get the knee point of the image of the skeleton were observed, must find the length of the foot image of the skeleton, then the result divided by two. To find the length of the foot, a few things done are:

- Find the length of the forefoot. To get the length of the front foot, do the iteration process.
- If found the number 0, then the rows of the coordinate values of pixels that have a value of 0 is stored in an array in BLD variables (variables that indicate the length of the front legs).
- Value of the front row of the knee obtained by finding the mean of the values of variable BLD.
- Middle value is stored in the variable brsLututDpn.

After getting the value of the line your front knee, then look for the value of the back of the knee line. Process to find the value of the rear leg knee line, is as follows:

- Find the length of the rear legs by doing the iteration process.
- Iterative process is obtained from the values of the row is stored in the hind legs in the form of an array variable BLD.
- The values of the variables is sought BLD middle value, so to get a row from the back of the knee.

To find the difference in high-value features with a high front knee behind the knee (F1), made a deduction from the results of the front knee lines and the rear leg of the knee line.

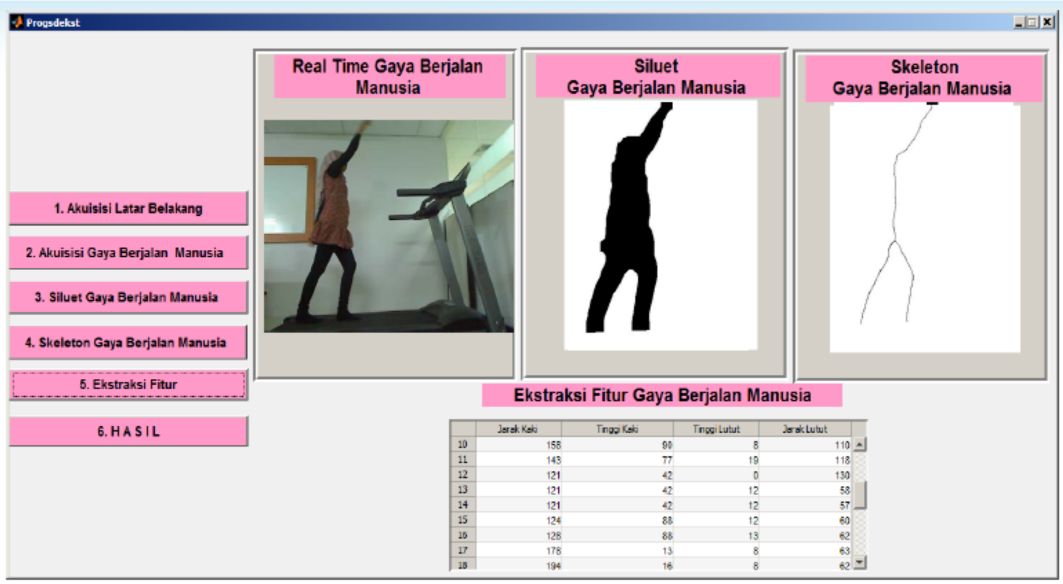
The second feature of the features of the knee is the distance between the front knee until the rear knee (F2). To find this feature F2, the process is almost the same as the search feature to the distance between the front foot with the heel of the hind legs, only for the features you are looking F2 value is the value column of the front knee and column values of the hind leg knee. Detailed process is as follows:

Nilai- The values of the variables is sought BLD middle value, so to get a row from the back of the knee.

- Find the coordinates of the column from the back of the knee line that has a value of 0 (black) koordinat kolom dari baris lutut kaki bagian belakang yang memiliki nilai 0 (hitam).
- Value of the front row of the knee obtained by finding the mean of the values of variable BLD.
- Find the coordinates of the column from the front line of the knee that has a value of 0 (black).
- Value column of the knee line and the rear legs stiff front knee lines reduced to each other and found the feature F2.

3. Hasil Dan Pembahasan

In order to test real time process and automation of human gait analysis using the interface (interface) in MATLAB as shown in Figure 8. At the beginning of the process interface is used to acquire a background of human gait and the objects of human gait are taken in real time. The next step is automatically new to the process of forming the silhouette and skeleton as well as the calculation of the feature extraction process consists of the distance between the front legs to the back of the heel, the difference in height between the front foot with the heel of the hind legs, the distance between the front knee to knee leg back, the difference height between the front knee behind the knee.

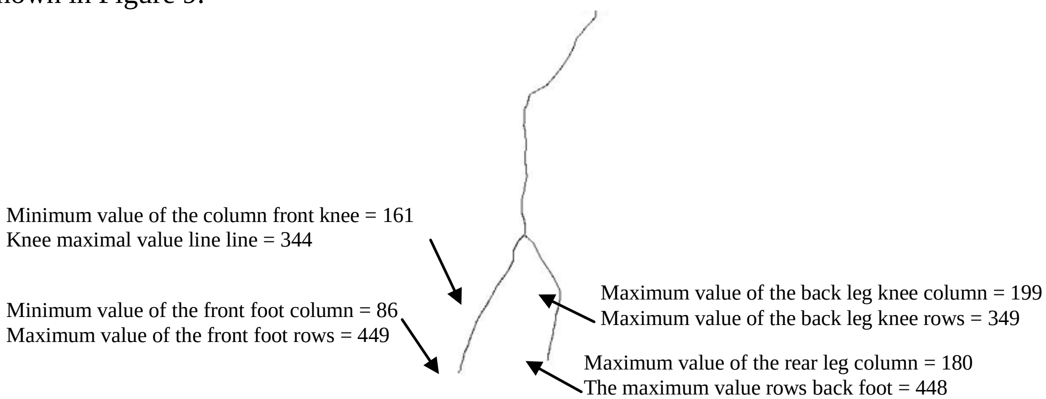


Gambar 8: Real Time Interface Process

Feature extraction distance between the front foot to back foot with the heel do with the reduction in the minimum column coordinates of the lower leg showing the location of the front foot column with a maximum value of the column where the column coordinates of the heel of the hind legs as shown in Figure 9.

Extraction of the difference in height between the front foot with the heel of the foot behind the line by reducing the maximum value column (the heel of the hind legs) with a minimum value of the column lines (front legs) as shown also in Figure 9.

Prior to feature extraction knee made the assumption that the central part of the foot of the image is the point of the knee. Then for the extraction of the distance between the front knee to knee back foot by reducing the minimum column of the front knee and the maximum value of the column behind the knee. While the extraction of the difference in height between the front knee behind the knee by reducing the maximum value of the rows in column (behind the knee) with a minimum value of the column lines (front knee) as shown in Figure 9.



Nilai Figure 9: The Columns And Rows Skeleton Frame Image

Furthermore the width and height measurements were taken per unit pixel using the equation:

Pixels per unit width = Width in centimeters Original / width in units of image pixels
Original height = Height in centimeters per unit pixels / High image in units of pixels

Illustration of the width of the retrieval of objects in inches, height in centimeters of space object retrieval, image width and height in units of image pixels in units of pixels shown in figure 10.

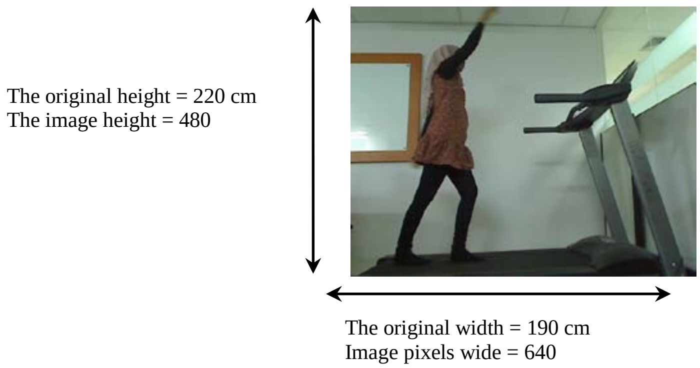


Figure 10: The Human gait Frame Acquisition

By using the values in Figure 9 and 10 will then automatically generate the calculation of extraction algorithms for image 9 is as follows:
minimum value of the front leg columns = 86; the maximum value back foot column = 180; the maximum value = 448 rows forelegs; the maximum value = 449 lines of rear legs; the minimum front knee column = 161; the maximum value of the column behind the knee = 199; the maximum value front knee lines = 334; the maximum value behind the knee line = 349: Width = 190 cm Original: image width = 640 pixels; Height = 220 cm Original; image Height = 480 pixels.
Then the distance between the front foot with the heel of the foot to the rear

= | 180-86 | x 190cm / 640 pixels = 28.081 cm

Higher then the front foot with the heel of back foot

= | 449-448 | x 220 cm / 480 pixels = 0.562 cm

Then the distance between the front knee to knee back foot

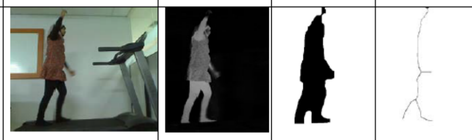
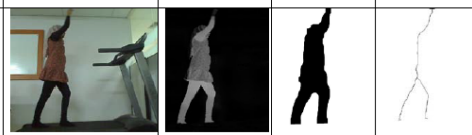
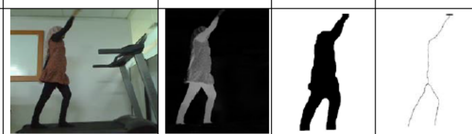
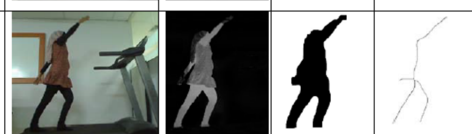
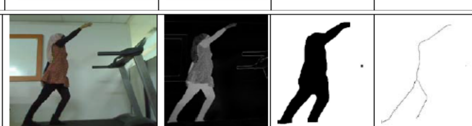
= | 161-199 | x 190 cm / 640 pixels = 12.367 cm

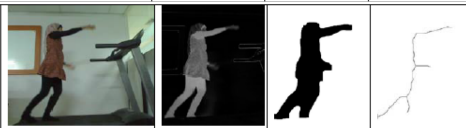
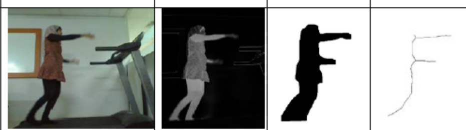
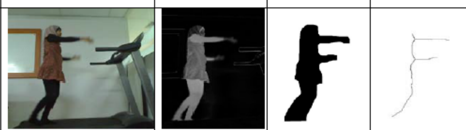
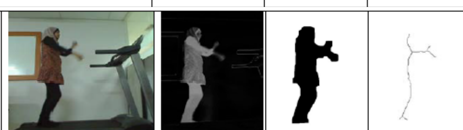
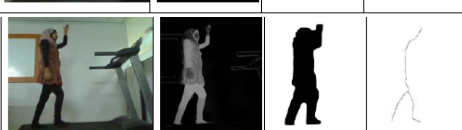
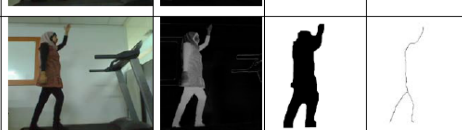
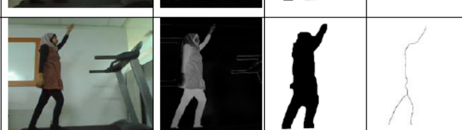
Height between the front foot with the heel of back foot

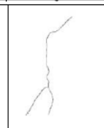
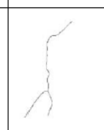
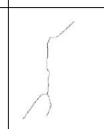
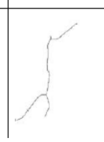
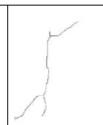
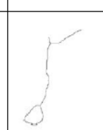
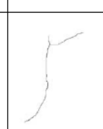
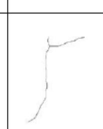
= | 344-349 | x 220 cm / 480 = 2.110 cm pikesel

Table 1 shows the skeleton detection and feature extraction for human gait cycle using a 32 frame image of the human gait in accordance with the test methods described in chapter 3. 32 frame image of the human gait reduction in the background as seen in the background of the reduction column in Table 1. Then the reduction of the background image frame is formed as shown in column silhouette silhouette. 32 frame silhouette is processed to detect the skeleton as shown in column form skeleton. Eight of the last column shows the results of ideal and scalable feature extraction (using an automatic algorithm) the distance between the front legs to the back of the heel, the difference in height between the front foot with the heel of the hind legs, the distance between the front knee to knee and back foot difference in height between the knee front with the rear knee.

Table 1. Results Detection of Skeleton A Walk Cycle

No Frame	Akusisi gaya berjalan manusia Secara *real time*	Pengurangan Latar Belakang	Bentukan siluet	Deteksi *Skeleton Skeleton*	Jarak kaki Ideal (cm)	Jarak kaki terukur (cm)	Tinggi kaki ideal (cm)	Tinggi kaki terukur (cm)	Jarak Lutu ideal (cm)	Jarak Lutu terukur (cm)	Tinggi Lutut Ideal (cm)	Tinggi Lutut terukur (cm)
1.					32,725	32,303	3,254	3,259	14,867	14,467	2,098	2,110
2.					28,800	28,925	0,642	0,562	14,543	15,051	2,098	2,110
3.					28,503	28,081	0,642	0,562	12,915	12,367	2,098	2,110
4.					28,800	28,081	0,642	0,562	11,895	11,550	1,702	1,690
5.					28,206	28,081	0,642	0,562	10,543	10,152	1,108	1,124
6.					28,206	27,764	0,642	0,562	8,256	8,518	1,108	1,124
7.					27,909	27,764	0,642	0,562	7,229	7,350	0,435	0,424
8.					28,206	27,764	0,642	0,562	7,219	7,117	0,158	0,143
9.					28,206	27,764	0,642	0,562	6,894	6,884	0,277	0,281
10.					28,206	27,764	0,642	0,562	6,244	6,533	0,435	0,424
11.					17,694	17,314	7,975	6,895	13,765	14,119	7,046	7,038

No Frame	Akusisi gaya berjalan manusia Secara *real time*	Pengurangan Latar Belakang	Bentukan siluet	Deteksi *Skeleton Skeleton*	Jarak kaki Ideal (cm)	Jarak kaki terukur (cm)	Tinggi kaki ideal (cm)	Tinggi kaki terukur (cm)	Jarak Lutu ideal (cm)	Jarak Lutu terukur (cm)	Tinggi Lutut Ideal (cm)	Tinggi Lutut terukur (cm)
12.					20,633	20,585	8,479	7,319	15,202	15,635	7,758	7,743
13.					23,854	23,753	3,438	2,957	16,797	16,685	7,046	7,038
14.					26,152	26,814	1,788	1,548	17,227	17,502	7,481	7,461
15.					27,963	28,399	2,796	2,395	17,994	18,434	6,888	6,895
16.					28,571	29,453	3,117	2,676	18,513	19,251	6,492	6,476
17.					29,821	29,875	10,129	8,728	17,853	17,853	6,333	6,333
18.					34,823	34,942	10,588	9,148	15,248	15,753	5,898	5,914
19.					30,670	29,981	11,917	10,276	15,766	15,284	5,502	5,490
20.					30,231	29,664	10,908	9,433	16,603	16,570	6,333	6,333
21.					27,123	27,975	9,442	8,162	15,156	15,517	5,581	5,561
22.					26,835	26,499	11,229	9,714	13,991	14,352	6,848	6,828
23.					23,495	24,175	11,596	9,995	12,587	12,951	7,758	7,743

No Frame	Akusisi gaya berjalan manusia Secara *real time*	Pengurangan Latar Belakang	Bentukan siluet	Deteksi *Skeleton Skeleton*	Jarak kaki Ideal (cm)	Jarak kaki terukur (cm)	Tinggi kaki ideal (cm)	Tinggi kaki terukur (cm)	Jarak Lutu ideal (cm)	Jarak Lutu terukur (cm)	Tinggi Lutut Ideal (cm)	Tinggi Lutut terukur (cm)
24.					22,037	22,275	12,558	10,838	9,867	9,568	6,610	6,614
25.					22,358	22,171	14,850	12,809	9,758	9,450	7,481	7,461
26.					19,849	19,953	13,521	11,681	9,808	9,450	10,846	10,838
27.					18,703	18,475	0,000	0,000	10,841	11,084	10,688	10,699
28.					19,297	19,635	0,000	0,000	13,821	13,653	8,669	8,657
29.					16,328	16,257	0,000	0,000	11,491	11,317	5,621	5,629
30.					19,493	19,953	8,479	7,319	13,312	13,653	5,621	5,629
31.					23,177	24,703	9,946	8,586	16,341	16,334	3,523	3,519

Calculation of distance and height is ideal for manual measurement of human gait original image acquired in real time on the image 11 using the distance formula $D = \sqrt{(x_1 - x_2)^2 + (y_1 - y_2)^2}$ and for high-use formula $|y_2 - y_1|$.

Figure 11: The Human gait Frame Acquisition

By using the values in Figure 11 and 10 then the calculation of the distance and the high ideal of the feet and knees are as follows:

front foot value X = 84; the back foot X = 180; the hind Y = 448; the forefoot Y = 449; the front knee X = 160; the back of the knee X = 199; the front knee Y = 344; value rear knee Y = 349; Original space width = 190 cm; image acquisition space width = 640 pixels; Height = 220 cm The original space; Image Height = 480 pixels of space acquisition

Then the distance between the front foot with the heel of the foot to the rear

$$= \sqrt{|180 - 84|^2 + |449 - 448|^2} \text{ x } 190\text{cm} / 640 \text{ piksel} = 28{,}503 \text{ cm}$$

Higher then the front foot with the heel of back foot

$$= |449 - 448| \text{ x } 220 \text{ cm} / 480 \text{ piksel} = 0{,}642 \text{ cm}$$

Then the distance between the front knee to knee back foot

$$= \sqrt{|160 - 199|^2 + |344 - 349|^2} \text{ x } 190 \text{ cm} / 640 \text{ piksel} = 12{,}915 \text{ cm}$$

Higher then the front foot with the heel of back foot

$$= |344 - 349| \text{ x } 220 \text{ cm} / 480 \text{ piksel} = 2{,}098 \text{ cm}$$

The results of feature extraction and the ideal distance and height measured from the foot and knee to 32 frames in one cycle of human gait shown in Table 2 and Table 3.

Table 2. Distance Feature Extraction results Feet High And Ideal and Measured

No	Ideal Feet Distance	Leg Distance Measured	Percentage Error Distance	Ideal Feet High	Measured Feet High	Presentation High Error
1	32,725	32,303	0,030	3,254	3,259	0,010
2	28,800	28,925	0,030	0,642	0,562	0,010
3	28,503	28,081	0,040	0,642	0,562	0,010
4	28,800	28,081	0,030	0,642	0,562	0,010
5	28,206	28,081	0,040	0,642	0,562	0,010
6	28,206	27,764	0,030	0,642	0,562	0,010
7	27,909	27,764	0,020	0,642	0,562	0,030
8	28,206	27,764	0,010	0,642	0,562	0,110
9	28,206	27,764	0,000	0,642	0,562	0,010
10	28,206	27,764	0,040	0,642	0,562	0,030
11	17,694	17,314	0,030	7,975	6,895	0,000
12	20,633	20,585	0,030	8,479	7,319	0,000
13	23,854	23,753	0,010	3,438	2,957	0,000
14	26,152	26,814	0,020	1,788	1,548	0,000
15	27,963	28,399	0,020	2,796	2,395	0,000
16	28,571	29,453	0,040	3,117	2,676	0,000
17	29,821	29,875	0,000	10,129	8,728	0,000
18	34,823	34,942	0,030	10,588	9,148	0,000
19	30,670	29,981	0,030	11,917	10,276	0,000
20	30,231	29,664	0,000	10,908	9,433	0,000
21	27,123	27,975	0,020	9,442	8,162	0,000

No	Ideal Feet Distance	Leg Distance Measured	Percentage Error Distance	Ideal Feet High	Measured Feet High	Presentation High Error
22	26,835	26,499	0,030	11,229	9,714	0,000
23	23,495	24,175	0,030	11,596	9,995	0,000
24	22,037	22,275	0,030	12,558	10,838	0,000
25	22,358	22,171	0,030	14,850	12,809	0,000
26	19,849	19,953	0,040	13,521	11,681	0,000
27	18,703	18,475	0,020	0,000	0,000	0,000
28	19,297	19,635	0,010	0,000	0,000	0,000
29	16,328	16,257	0,020	0,000	0,000	0,000
30	19,493	19,953	0,020	8,479	7,319	0,000
31	23,177	24,703	0,000	9,946	8,586	0,000
32	27,354	27,449	0,030	10,908	9,433	0,000

In table 1 the distance and height of the feet is ideal pengukuruan manual to the human gait in real time in figure 11. While distance and distance measured is the result of the automatic calculation of skeleton image in Figure 9. The average percentage error comparison between the distances measured by the foot of ideal foot distance is 2%. While the average percentage error comparison of high antra feet measured with a high ideal foot is 1%.

Table 3. Distance Feature Extraction And Knee High Ideal and Measured

No	Distance Knee Ideal	Distance Measured Measured	Percentage Error Distance	Knee High Ideal	Knee High Measured	Presentation High Error
1	14,867	14,467	0,03	5,300	5,330	0,01
2	14,543	15,051	0,03	5,300	5,330	0,01
3	12,915	12,367	0,04	5,300	5,330	0,01
4	11,895	11,550	0,03	4,300	4,270	0,01
5	10,543	10,152	0,04	2,800	2,840	0,01
6	8,256	8,518	0,03	2,800	2,840	0,01
7	7,229	7,350	0,02	1,100	1,070	0,03
8	7,219	7,117	0,01	0,400	0,360	0,11
9	6,894	6,884	0,00	0,700	0,710	0,01
10	6,244	6,533	0,04	1,100	1,070	0,03
11	13,765	14,119	0,03	17,800	17,780	0,00
12	15,202	15,635	0,03	19,600	19,560	0,00
13	16,797	16,685	0,01	17,800	17,780	0,00
14	17,227	17,502	0,02	18,900	18,850	0,00
15	17,994	18,434	0,02	17,400	17,420	0,00
16	18,513	19,251	0,04	16,400	16,360	0,00
17	17,853	17,853	0,00	16,000	16,000	0,00
18	15,248	15,753	0,03	14,900	14,940	0,00
19	15,766	15,284	0,03	13,900	13,870	0,00
20	16,603	16,570	0,00	16,000	16,000	0,00
21	15,156	15,517	0,02	14,100	14,050	0,00

No	Distance Knee Ideal	Distance Measured Measured	Percentage Error Distance	Knee High Ideal	Knee High Measured	Presentation High Error
22	13,991	14,352	0,03	17,300	17,250	0,00
23	12,587	12,951	0,03	19,600	19,560	0,00
24	9,867	9,568	0,03	16,700	16,710	0,00
25	9,758	9,450	0,03	18,900	18,850	0,00
26	9,808	9,450	0,04	27,400	27,380	0,00
27	10,841	11,084	0,02	27,000	27,030	0,00
28	13,821	13,653	0,01	21,900	21,870	0,00
29	11,491	11,317	0,02	14,200	14,220	0,00
30	13,312	13,653	0,02	14,200	14,220	0,00
31	16,341	16,334	0,00	8,900	8,890	0,00
32	17,253	17,735	0,03	7,800	7,820	0,00

Table 2 the distance and height of the knee is pengukuruan ideal manual for the human gait in real time in figure 11. While distance and distance measured is the result of the automatic calculation of skeleton image in Figure 9. The average percentage error comparison between the distances measured by the foot of ideal foot distance is 2%. While the average percentage error comparison of high antra feet measured with a high ideal foot is 1%.

By doing a comparison between the calculated automatically by calculation manually, the error rate below 2% so it can be said skeleton detection and feature extraction of human gait is almost equal to the actual.

4. Conclusion and Suggestions

Based on the test results of the proposed algorithm, it can be concluded as follows:

- Method of acquisition of human gait in real time successfully perform rapid acquisition of human gait and the data of human gait can be directly processed to detect the skeleton and extracting features automatically, quickly and accurately.
- Methods and background reduction algorithms can effectively separate the object mensegmentasi and ongoing human body from other objects in the image captured by the Webcam. This method produces a silhouette of the human body that are running.
- Algorithm skeletonizing and thinning of the human body silhouette running to produce the skeleton of the human body is almost like the real form.
- Calculation of the features of human gait: the distance between the front legs to the back of the heel, the difference in height between the front foot with the heel of the hind legs, the distance between the front knee to knee and back foot difference in height between the front knee behind the knee can be done automatically without operator intervention or non-intrusive in a relatively fast.

The proposed suggestion of the study are:

- The algorithm skeleton detection and feature extraction of non-intrusive to the human gait in real time that have been developed to generate the skeleton of the human body is almost like the real form. But the new feature extraction performed on both legs of the body. Therefore, the need to have additional features that are extracted from other body parts.
- Objects of human gait tested on a prototype software is still using common objects of human gait. In order for this software can diimpelementasi in the medical field for diagnosing and finding an illness

in patients in patients with abnormal gait and in the field of sports to improve performance of athletes, it is necessary to test using data on medical and sports fields.

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